I. RECOMMENDATIONS FOR A CARBON DISULFIDE STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to carbon disulfide in the workplace be controlled by adherence to the following sections. The standards are designed to protect the health and provide for the safety of workers for up to a 10-hour work shift, 40-hour workweek, over a working lifetime. Compliance with all sections of the standard should prevent adverse effects of carbon disulfide on the health and safety of workers. Because of possible synergism or additiveness of toxic effects, the concentration of hydrogen sulfide shall be minimized when carbon disulfide and hydrogen sulfide coexist. Techniques recommended in the standard are valid, reproducible, and available to industry and government agencies. The criteria and standard will be subject to review and revision as necessary.

Neurologic, behavioral, psychologic, cardiovascular, reproductive, and other abnormalities have been found in workers exposed to carbon disulfide. However, several issues complicate the development of a standard for occupational exposure to carbon disulfide. All human exposure information used in this document is based on worker experience in the viscose rayon industry, in which there is exposure to both carbon disulfide and hydrogen sulfide. Exposure to carbon disulfide is generally minimal during the workday but may occasionally reach high concentrations for short periods of time. Neither the possible synergism of hydrogen sulfide and carbon disulfide nor the effects of the peak exposures have been adequately

studied. Another major issue in this document is the reports of adverse effects on reproductive function. These studies, however, did not report sampling or analytical methods or provide adequate detail on occupational exposure concentrations.

The term "carbon disulfide," in this document, refers to either vaporized or liquid carbon disulfide. Synonyms for carbon disulfide include carbon bisulfide, carbon sulfide, and dithiocarbonic anhydride. "Occupational exposure to carbon disulfide" is defined as exposure to airborne carbon disulfide at or above half the recommended time-weighted average (TWA) concentration limit or contact of skin or eyes with liquid carbon disulfide. Where there is no occupational exposure to carbon disulfide, adherence is required to Sections 3, 4(a), 4(b), 5, 6, 7, and 8 only.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Employee exposure to carbon disulfide shall be controlled so that no worker is exposed to carbon disulfide at a concentration greater than 3 milligrams of carbon disulfide per cubic meter of air (1 part per million parts of air by volume) determined as a TWA concentration for up to a 10-hour work shift in a 40-hour workweek, or to more than 30 mg carbon disulfide/cu m of air (10 ppm) as a ceiling concentration for any 15 minute period.

(b) Sampling and Analysis

Procedures for sampling and analysis of workplace air shall be as provided in Appendices I and II, or by any methods shown to be at least equivalent to the methods specified in precision, accuracy, and sensitivity.

Section 2 - Medical

Medical surveillance shall be made available as outlined below to all workers subject to occupational exposure to carbon disulfide.

(a) Preplacement examinations shall include:

(1) Comprehensive medical and work histories with special emphasis directed toward the cardiovascular, reproductive, and nervous systems and medicine being taken.

(2) Physical examination giving particular attention to neurologic function and cardiovascular evaluation including an electrocardiogram (ECG).

(3) A judgment of the worker's ability to use positive and negative pressure respirators.

(b) Periodic examinations shall be made available on at least an annual basis. These examinations shall include:

(1) Interim medical and work histories.

(2) Physical examination as outlined in (a)(2) above, with attention especially to behavioral and psychologic changes.

(c) The iodine-azide urine test may be administered periodically to a sample of workers with occupational exposure to carbon disulfide. The

frequency of the iodine-azide urinalyses may vary, according to the judgment of the physician and the industrial hygienist. Each exposed worker should have the opportunity to receive a urinalysis at least yearly. Procedures for this biologic monitoring are described in Appendix III. Workers whose postshift specimens yield an exposure coefficient (E) below 6.5 should receive an appropriate medical examination, a review of his or her work habits, and should be reassigned to a nonexposed area of the plant until the iodine-azide test results are negative (E>6.5) or the responsible physician authorizes him to do so.

(d) During examinations, applicants or employees with medical conditions which would be directly or indirectly aggravated by exposure to carbon disulfide shall be counseled on the increased risk of impairment of their health from working with this substance and on the value of periodic examinations. The employee shall be advised of potential undesirable effects of exposure to carbon disulfide on reproduction, such as spermatic deficiencies, menstrual disorders, and spontaneous abortions.

(e) Initial medical examinations shall be made available to all workers within six months after the promulgation of a standard based on these recommendations.

(f) If an emergency involving carbon disulfide arises, a qualified medical attendant designated by the employer shall examine all exposed employees. In case of eye contact with carbon disulfide, the eyes shall be flushed immediately with large amounts of water for 15 minutes. Copious amounts of water and a mild soap shall be used to cleanse skin which has come in contact with carbon disulfide. Emergency medical procedures shall be posted where carbon disulfide is used, and employees shall be trained in

these procedures. In case of severe overexposure, the worker should be removed to an area with fresh air, respiration should be maintained, and a physician should be summoned immediately.

(g) Pertinent medical records shall be maintained for all employees involved in manufacturing, processing, or handling carbon disulfide or who are or in any other way exposed to carbon disulfide in the workplace. Such records shall be kept for at least 30 years after termination of employment. These records shall be made available to the designated medical representative of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employer, and of the employee or former employee.

Section 3 - Labeling and Posting

All containers of carbon disulfide shall be labeled, and all areas where carbon disulfide is stored, handled, used, or produced shall be posted in accordance with the following subsections.

All warning signs and labels shall be printed in English and in the predominant language of non-English-reading workers. The employer shall ensure that employees unable to read the warning labels and signs are informed of the hazards of working with carbon disulfide, of the hazardous work areas, and of the self-help and first-aid procedures to be employed in case of intoxication by the vapor of carbon disulfide or contact of skin and eyes with liquid carbon disulfide.

(a) Containers of carbon disulfide shall bear the following label in addition to, or in combination with, labels required by other statutes, regulations, or ordinances:

CARBON DISULFIDE

EXTREMELY FLAMMABLE AND HAZARDOUS TO HEALTH
KEEP AWAY FROM FIRE, SPARKS, OR HEATED SURFACES

Do not breathe vapor.
Avoid contact with skin and eyes.
Use only with adequate spark-proof ventilation.

First Aid: Remove patient to fresh air. Administer artifical respiration if breathing has stopped. Keep patient warm; consult a physician. In case of skin or eye contact, flush with copious amounts of water.

(b) The following warning sign shall be posted in a readily visible location at or near entrances to areas where carbon disulfide is stored, handled, used, or produced:

CARBON DISULFIDE

WARNING--HAZARDOUS AREA

EXTREMELY FLAMMABLE AND HAZARDOUS TO HEALTH

Do not breathe vapor.
Keep flames, sparks, and bare light bulbs away.
Use only with adequate spark-proof ventilation.

First Aid: Remove patient to fresh air. Administer artificial respiration if breathing has stopped. Keep patient warm; consult a physician. In case of skin or eye contact, flush with copious amounts of water.

Section 4 - Personal Protective Clothing and Equipment

Employers shall use engineering controls and safe work practices to keep exposure to carbon disulfide below the prescribed limits. When necessary, these shall be supplemented by the use of personal protective equipment and clothing. Requirements for personal protective equipment shall be as provided in 29 CFR 1910, Subpart I. Emergency equipment shall be readily available to the work area and shall be adequate to permit all employees to escape safely from the area. Protective equipment suitable for emergency entry shall be located at clearly identified stations outside the area of possible occupational exposure.

(a) Skin Protection

Employers shall provide protective clothing and shall ensure that employees use appropriate skin protection when contact with liquid carbon disulfide is possible. Synthetic rubber gloves shall be provided, and employees should be cautioned not to allow their gloved hands to remain immersed in carbon disulfide for extended periods. Other glove materials of comparable effectiveness may also be used.

(b) Eye Protection

Face shields (8-inch minimum) with goggles shall be worn by employees working with liquid carbon disulfide wherever splashes are likely to occur.

(c) Respiratory Protection

(1) Respiratory protective equipment shall be used to protect employees from air concentrations of carbon disulfide which may exceed the recommended environmental limit in the following circumstances only:

(A) During the time necessary to install and test the controls required in Section 6(b) of this chapter.

(B) For nonroutine operations, such as maintenance or repair activities, causing exposure in excess of the TWA concentration limit.

(C) In emergencies when air concentrations of carbon disulfide may exceed the TWA exposure limit.

(D) Respirators specified for use in higher concentrations of carbon disulfide may be used in atmospheres of lower concentrations.

(2) When a respirator is permitted by paragraph (1) of this subsection, it shall be selected in accordance with the specifications in Tables I-1 and I-2 and shall comply with the standards jointly approved by NIOSH and the Mining Enforcement and Safety Administration (MESA) as specified in 30 CFR 11. Employers shall establish and enforce a respiratory protection program meeting the requirements of 29 CFR 1910.134, as amended, and shall ensure that employees use required respiratory protective equipment.

(3) Employers shall ensure that respirators are properly cleaned and maintained and that employees are trained and drilled in the location and use of respirators assigned to them and in testing for leaks.

TABLE I-1

RESPIRATOR SELECTION GUIDE FOR CARBON DISULFIDE

Concentration	Respirator Type Approved Under Provisions of 30 CFR 11
Less than or equal to 30 mg/cu m	(1) Chemical cartridge respirator with half-mask facepiece and organic vapor cartridge (2) Supplied-air respirator operated in demand (negative pressure) mode with half-mask facepiece
Less than or equal to 150 mg/cu m	(1) Gas mask with chin-style or front- or back-mounted organic vapor canister with full facepiece (2) Supplied-air respirator in demand (negative pressure) mode with full facepiece (3) Self-contained breathing apparatus operated in demand (negative pressure) mode with full facepiece
Less than or equal to 3,000 mg/cu m	(1) Supplied-air respirator with full facepiece operated in pressure demand or other positive pressure mode (2) Supplied-air hood, helmet, or suit operated in continuous-flow mode
Greater than 3,000 mg/cu m	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode and auxiliary self-contained air supply
Emergency (entry into area of unknown concentration for emergency purposes such as firefighting)	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode and auxiliary self-contained air supply

TABLE I-2

RESPIRATOR SELECTION GUIDE FOR CARBON DISULFIDE PLUS HYDROGEN SULFIDE

Concentration		Respirator Type Approved Under Provisions of 30 CFR 11
Hydrogen Sulfide	Carbon Disulfide	
Less than or equal to 35 mg/cu m	Less than or equal to 150 mg/cu m	(1) Gas mask with combination chin-style or front- or back-mounted canister for both organic vapor and acid gas, equipped with full facepiece (2) Supplied-air respirator with full facepiece operated in demand (negative pressure) mode (3) Self-contained breathing apparatus operated in demand (negative pressure) mode with full facepiece
Less than or equal to 280 mg/cu m	Less than or equal to 3,000 mg/cu m	(1) Supplied-air respirator with full facepiece operated in continuous-flow, pressure-demand, or other positive pressure mode (2) Supplied-air hood, helmet, or suit operated in continuous-flow mode
Greater than 280 mg/cu m	Greater than 3,000 mg/cu m	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode and auxiliary self-contained air supply
Emergency (entry into area of unknown concentration for emergency purposes such as firefighting)		(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode and auxiliary self-contained air supply

Section 5 - Informing Employees of Hazards from Carbon Disulfide

Employees who will work in areas required to be posted in accordance with Section 3 shall be informed of the hazards from carbon disulfide exposure, symptoms of overexposure, emergency and first-aid procedures, and precautions to ensure safe use and to minimize exposure. Employers shall post this information in the workplace and shall keep it on file, readily accessible to employees.

Employers shall institute a continuing education program, conducted at least annually by persons qualified by experience or training, for employees whose jobs may involve exposure to carbon disulfide. This is to ensure that all such employees have current knowledge of job hazards, maintenance procedures, and cleanup methods, and that they know how to use respiratory protective equipment and protective clothing. The instructional program shall include a description of medical surveillance procedures and of the advantages to the employee of undergoing these examinations. As a minimum, instruction shall include the information described in Appendix IV. Employees engaged in maintenance and repair shall be included in training programs. Employees of the viscose rayon industry should be informed of the possibility that exposure to both hydrogen sulfide and carbon disulfide may be more hazardous than exposure to either compound alone.

Required information shall be recorded as specified in Appendix IV, on a "Material Safety Data Sheet," or a similar form approved by the Occupational Safety and Health Administration, US Department of Labor, and shall be kept on file, readily accessible to employees.

Section 6 - Work Practices

(a) Emergency Procedures

For all work areas where there is a potential for emergencies involving carbon disulfide, employers shall take all necessary steps to ensure that employees are instructed in and follow the procedures specified below and any others appropriate for the specific operation or process.

(1) Instructions shall include designation of medical receiving facilities and prearranged plans for immediate evacuation of employees exposed to potentially life-threatening concentrations of carbon disulfide; for any necessary calls for assistance, including alerting medical facilities to the impending arrival of overexposed employees and calls to suppliers or manufacturers of carbon disulfide for any necessary technical advice; and for reentry for repairs or cleanup of areas where carbon disulfide leaks or spills have occurred.

(2) Telephone numbers for emergency assistance shall be prominently posted.

(3) Employees not essential to emergency operations shall be evacuated from hazardous areas during emergencies. Perimeters of these areas shall be delineated, posted, and secured.

(4) Only personnel adequately protected against the attendant hazards shall shut off sources of carbon disulfide, clean up spills, and control and repair leaks.

(5) Approved eye, skin, and respiratory protection as specified in Section 4 shall be used by personnel essential to emergency operations.

(6) In case of fire, carbon disulfide containers should be removed to a safe place, if possible, or cooled with water if leaks do not exist.

(7) Carbon disulfide in contact with skin or eyes shall be removed by immediate flushing with copious quantities of water for 15 minutes, and immediate medical attention shall be obtained. Clothing contaminated with carbon disulfide shall be removed promptly and replaced with clean clothing.

(8) Employees incapacitated by carbon disulfide shall be removed to an uncontaminated atmosphere and given artificial respiration, following the back-pressure method of removing toxic gases from the victim. Victims shall be kept quiet and warm and given immediate medical attention.

(b) Control of Airborne Carbon Disulfide

Engineering controls shall be used when needed to keep carbon disulfide concentrations below the recommended limits. Local exhaust ventilation may also be effective, used alone or in combination with process enclosure. Spark-proof ventilation systems shall be designed to prevent recirculation of air in the workroom, to keep concentrations of carbon disulfide below the recommended occupational exposure limit, and to remove carbon disulfide from the breathing zones of workers. Ventilation systems shall be subject to regular preventive maintenance and cleaning to ensure effectiveness, which shall be verified by periodic airflow measurement. Makeup air shall be provided to workrooms in which exhaust ventilation is operating.

(c) Storage

Drums of liquid carbon disulfide shall not be stored in direct sunlight or near a source of heat. The storage area should be fire resistant, cool, and either open or well ventilated at floor level. The storage area shall be equipped with an adequate supply of portable fire extinguishers and automatic sprinklers. Bulk tanks of carbon disulfide placed aboveground should be surrounded by dikes. Such tanks may also be buried or immersed in pits under a blanket of water.

(d) Waste Disposal

(1) Disposal of carbon disulfide shall conform to all applicable local, state, and federal regulations.

(2) Carbon disulfide shall not be allowed to enter drains or sewers.

(e) Confined Spaces

(1) Entry into confined spaces such as tanks, pits, tank cars, barges, process vessels, and tunnels shall be controlled by a permit system or other program offering equal protection. Precautions shall be taken to ensure that procedures prescribed below are followed.

(2) Confined spaces which have contained carbon disulfide shall be inspected by employees wearing proper respiratory protective equipment in accordance with Table I-1 or I-2. These areas shall be tested for oxygen deficiency, carbon disulfide, and other contaminants and shall be thoroughly ventilated, cleaned, neutralized, and washed, as necessary, prior to entry of employees without respiratory protection.

(3) Confined spaces shall be ventilated while employees are within them to keep the concentration of carbon disulfide below the

recommended environmental limit and to prevent oxygen deficiency.

(4) When a person enters a confined space, another properly protected worker shall be on standby outside.

(f) Maintenance

Periodic maintenance shall be required on all equipment and machinery in areas of potential carbon disulfide exposure. Firefighting equipment and other emergency equipment shall be maintained in good working order, as prescribed by local, state, or federal regulations.

Section 7 - Sanitation

(a) Eating and food preparation or dispensing (including vending machines) shall be prohibited in carbon disulfide work areas.

(b) Smoking shall not be permitted in areas where carbon disulfide is used, transferred, stored, manufactured, or released as a result of chemical processes.

(c) Employees who handle carbon disulfide or equipment contaminated with carbon disulfide shall be instructed to wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

(d) Waste material contaminated with carbon disulfide shall be disposed of in a manner not hazardous to employees. The disposal method must conform to applicable local, state, and federal regulations and must not constitute a hazard to the surrounding population or environment.

(e) Plant sanitation shall meet the requirements of 29 CFR 1910.141.

Section 8 - Monitoring and Recordkeeping Requirements

Within 6 months of the promulgation of a standard based on these recommendations, employers shall determine by an industrial hygiene survey at each location where carbon disulfide is released into workplace air whether employee exposures to the compound may be above one-half the recommended TWA concentration limit. Employers shall keep records of these surveys. If an employer concludes that air concentrations are at or below one-half the recommended limit, the records must show the basis for this conclusion. Surveys shall be repeated at least annually and within 30 days after any process change likely to result in increased airborne carbon disulfide concentrations. In those years with no scheduled surveys, employers shall conduct semiannual sampling (area and personal monitoring) to determine employee exposure. If it has been determined that the environmental concentration of carbon disulfide might exceed one-half the recommended occupational exposure limit, ie, 0.5 ppm as a TWA concentration, then the employer shall fulfill the following requirements:

(a) Personal Monitoring

(1) A program of personal monitoring shall be instituted to determine the exposure of each employee occupationally exposed to carbon disulfide. Source and area monitoring may be used to supplement personal monitoring.

(2) In all personal monitoring, samples representative of the exposure in the breathing zone of the employee shall be collected. Procedures for sampling, calibration of equipment, and analysis of carbon disulfide samples shall be as provided in Section 1(b).

(3) For each determination of the TWA concentration of carbon disulfide, a sufficient number of samples shall be taken to characterize the employee's exposure. Variations in the employee's work schedule, location, and duties and changes in production schedules shall be considered when samples are collected.

(4) If an employee is found to be exposed to a concentration of carbon disulfide above one-half the recommended TWA occupational exposure limit, the exposure of that employee shall be monitored at least once every 3 months. If an employee is found to be exposed at or above the recommended TWA concentration limit, the exposure of that employee shall be measured at least once every week, control measures shall be initiated, and the employee shall be notified of the exposure and of the control measures being implemented. Such monitoring shall continue until two consecutive determinations, at least 1 week apart, indicate that the employee's exposure no longer exceeds the recommended occupational exposure limit; quarterly or less frequent monitoring may then be resumed in accordance with the paragraphs above.

(b) Recordkeeping

Records of environmental monitoring shall be maintained for at least 30 years after the termination of employment. These records shall include the name of the employee being monitored, duties and job locations within the worksite, dates of measurements, sampling and analytical methods used, evidence of their accuracy, duration of sampling, number of samples taken, results of analysis of TWA concentration determinations based on these samples, and personal protective equipment in use by the employee. Records for each employee, indicating date of employment with the company and

changes in job assignment, shall be kept for the same 30-year duration. The employer shall make these records available on request to authorized representatives of the Assistant Secretary of Labor for Occupational Safety and Health and of the Director of the National Institute for Occupational Safety and Health. Employees, former employees, or their authorized representatives shall have access to information on the occupational exposures of the employee or former employee. The employee or the employee's representative shall be given the opportunity to observe any measurement conducted in accordance with this section. Any observer shall have the right to receive an explanation of the procedures used, the results of the measurement, and the measuring of the results for human health and safety.

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases or injuries arising from exposure to carbon disulfide. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "...develop criteria dealing with toxic materials and harmful physical agents and substances which will describe...exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health and to provide for the safety of workers exposed to hazardous chemical and physical agents. Criteria for an environmental standard should enable management and labor to develop better engineering controls and more healthful work practices and should not be used as a final goal.

These criteria for a standard for carbon disulfide are part of a continuing series of criteria developed by NIOSH. The proposed standard applies only to workplace exposure to carbon disulfide resulting from its processing, manufacture, storage, handling or use as applicable under the Occupational Safety and Health Act of 1970. This standard was not developed for the population-at-large, and any extrapolation beyond

occupational exposures is not warranted. It is intended to (1) protect against the fire hazards posed by carbon disulfide, (2) protect against the development of toxic effects of carbon disulfide exposure, (3) be measurable by techniques that are valid, reproducible, and available to industry and government agencies, and (4) be attainable with existing technology.

Neurologic, behavioral, psychologic, cardiovascular, and reproductive abnormalities have been found in workers in the viscose rayon industry. Studies of chronic human exposure to carbon disulfide have reported the concurrent presence of hydrogen sulfide, but possible toxic synergism has not been thoroughly investigated.

The development of the recommended standard for occupational exposure to carbon disulfide has revealed the need for additional data in several areas. The following research is needed: (1) studies designed to investigate possible synergism of toxic effects when carbon disulfide and hydrogen sulfide coexist; (2) studies to examine the toxicity of carbon disulfide when it occurs alone (ie, in industries other than viscose rayon manufacture); (3) further studies to evaluate the reproductive effects of carbon disulfide in humans and in animals; (4) additional epidemiologic studies conducted in the United States; (5) behavioral and psychologic tests for detection of preclinical symptoms of exposure; (6) studies of the role of the kidneys in the origination of the severe cardiovascular effects of exposure to carbon disulfide; (7) additional studies of dermal absorption of carbon disulfide; (8) development and validation of direct-reading sampling instrumentation; and (9) design of more efficient control technology.

Several critical issues complicate the development of a standard for occupational exposure to carbon disulfide. All human exposure information used in preparing the basis for the recommended occupational exposure limit has been taken from data on worker experience in the viscose rayon industry. Because of the nature of the process, hydrogen sulfide is always present with carbon disulfide. While the available evidence suggests an especially important role of carbon disulfide in development of the adverse health effects described in this document, the fact that simultaneous exposure to hydrogen sulfide occurs in this industry prevents any conclusive statement that hydrogen sulfide does not contribute to the observed effects. Exposure to carbon disulfide in the viscose rayon process is not constant during the workday. Exposure is typically minimal during most of the day but may reach high concentrations for short periods. The concentrations reported have generally been TWA concentrations and thus the effect of these peaks has not been adequately evaluated. Another major issue in this document pertains to the reports of reproductive system disorders occurring in workers exposed to carbon disulfide. The concentrations reported in these studies were low, but, because the sampling and analytical methods were not described and the concentrations were not adequately reported, these studies were not a major consideration in developing the recommended standard.

To provide the information needed for adequate protection of workers, a continuing, concerted effort is required by people concerned with the health and safety of employees exposed to carbon disulfide.